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Stellar kinematics of barred galaxies

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Abstract. I show that the counter-rotating core of the barred galaxy NGC 5728 could be explained by the internal dynamics of the bar. This supports the idea that the nuclear bar is counter-rotating.

1. Introduction

The advent of large telescopes (e.g. VLT) equipped with very sensitive spectrographs will make the obtaining of absorption lines spectra a routine task. The instrumental progress will increase our knowledge of stellar kinematics. Among the problems that will be addressed by such instruments, the *stellar bar* kinematics holds my attention since counter-rotating motion is now often observed in such galaxies. This paper is specially devoted to the interpretation of the stellar counter-rotating component observed in the double-barred galaxy NGC 5728 (Prada & Gutiérrez 1999).

2. The model

The generic 2D dynamical self-consistent model is one of the sets made by Wozniak & Pfenniger (1997). The mass model consists of a Ferrers ellipsoid (a/b/c=6/1.5/0.6 kpc, n=2) superposed on a Miyamoto-Nagai disk. The mass inside corotation is $0.32 \times 10^{11} M_{\odot}$. A set of orbits compatible with the mass distribution is numerically selected from a wide library using the Schwarzschild method. This technique gives the weight of the selected orbits. The distribution function is thus fully determined. This allows to compute the velocity field on a grid by averaging the velocities of each selected orbits weighted by their mass fraction. The distribution function of this model is very similar to those of N-body models. The mass on retrograde orbits inside corotation amounts to 19%.

3. Discussion

Although this model is not fitted for a detailed modeling of NGC 5728, the theoretical velocity field has been projected onto the plane of the sky using the projection angles of this object (i=48° and $\mathrm{PA}_{\mathrm{bar/line\ of\ nodes}}$=35°). A cut along the bar major axis simulates the slit of a spectrograph. In Fig. 1, we display the line-of-sight velocity (LOSV) curves obtained separately for direct

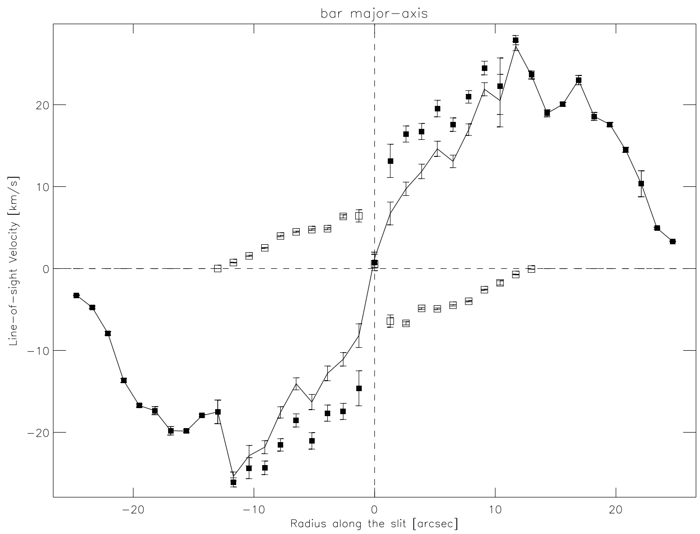

Figure 1. Numerical LOSV curves along the bar major-axis. The filled squares are for the LOSV computed with direct orbits. Open squares represent retrograde orbits. The line is the mass-weighted mean LOSV. The simulated slit width is $1.3''(\approx 300\,\mathrm{pc})$. The model is projected onto the plane of the sky as for NGC 5728

and retrograde orbits. Both components are separated by $\approx 20\,\mathrm{km.s^{-1}}$ which is not easily observable with current spectrographs. However, the theoretical velocities are obviously lower than those of NGC 5728 because the mass model does not match the real mass distribution. A more realistic model for this galaxy should be more massive, especially in the nucleus ($\approx 4 \times 10^9 M_\odot$ inside 300 pc) so that the gap between direct and retrograde velocities will increase. Thus, except for a scaling factor on velocities, the counter-rotating core found in the model is very likely of the same nature that the one of NGC 5728. The internal dynamics of the large-scale bar could thus explain the observations without the need to invoke any external origin.

Moreover, Prada & Gutiérrez (1999) suggested that the counter-rotating component is associated to the nuclear bar. As shown by N-body simulations (Friedli 1996) and discussed by Wozniak & Pfenniger (1997), this likely happens if a critical mass ratio is reached above which the counter-rotating bar dynamics is decoupled from the direct bar. However this model with only one large-scale bar plainly shows that a counter-rotating structure could be kinematically detected in barred galaxies whereas it is not photometrically observable.

Thanks to the improvements of spectrographs and algorithms of Gaussian decomposition (e.g. Kuijken & Merrifield 1993) it will become easy to detect such retrograde motions in barred galaxies in a near future.

References

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